Seeding Summer Ranges in Eastern Oregon and Washington

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Seeding Summer Ranges in Eastern Oregon and Washington

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INTRODUCTION

Range seeding, as an adjunct to good range management, is needed to increase the productivity of eastern Oregon and eastern Washington summer ranges. On about 600,000 acres, now yielding only a small percentage of their potential forage production, seeding is the only practicable way to reestablish a stable vegetative cover and increase the forage supply within a reasonable length of time.

This area is part of approximately 18.2 million acres of summer ranges east of the Cascade Mountains in Oregon and Washington (fig. 1). These summer ranges extend from the sagebrush-grass type at 2,500 to 5,000 feet, or from the lower portions of the ponderosa pine zone at 2,000 feet in northern Washington, up through the rest of the pine forest zone to the subalpine grasslands at 6,000 to 8,000 feet. Forested ranges, producing both forage and timber, amount to 15 million acres. Grasslands make up 1.5 million acres and mountain meadows about 700,000 acres, while the remaining 1 million acres of summer ranges are subalpine grasslands.

These ranges provide forage for 250,000 sheep and 150,000 cattle for 3 to 5 months during the summer. In addition, they are grazed by 270,000 deer and 75,000 elk for 9 or 10 months of the year. Even though the summer ranges are supporting this heavy load, the demand for summer forage is not being met.

While the forest ranges in this highly variable area are important for livestock and big-game production, they also are important for timber and water production. As human populations increase in the Pacific Northwest, demand for wood products and an orderly flow of high-quality water for domestic, agricultural, and industrial uses becomes greater and greater. Good range cover and stabilized soils are essential to assuring a sustained flow of water. Seeding can aid in the restoration of desirable conditions for these purposes where summer range areas have been depleted by heavy grazing or severely disturbed by fire, logging, or construction.

[1] The authors are indebted to A. L. Hafenrichter of the Nursery Division, Pacific Region, Soil Conservation Service, for his cooperation in furnishing seed used in many of the range seeding studies, for assistance on field problems, and for sharing his broad experiences with plants and range ecology, and to E. R. Jackman, Extension Service, Oregon State College, especially for his cooperation and assistance in planning and installing the studies and collecting data on Big Cow Creek Burn.

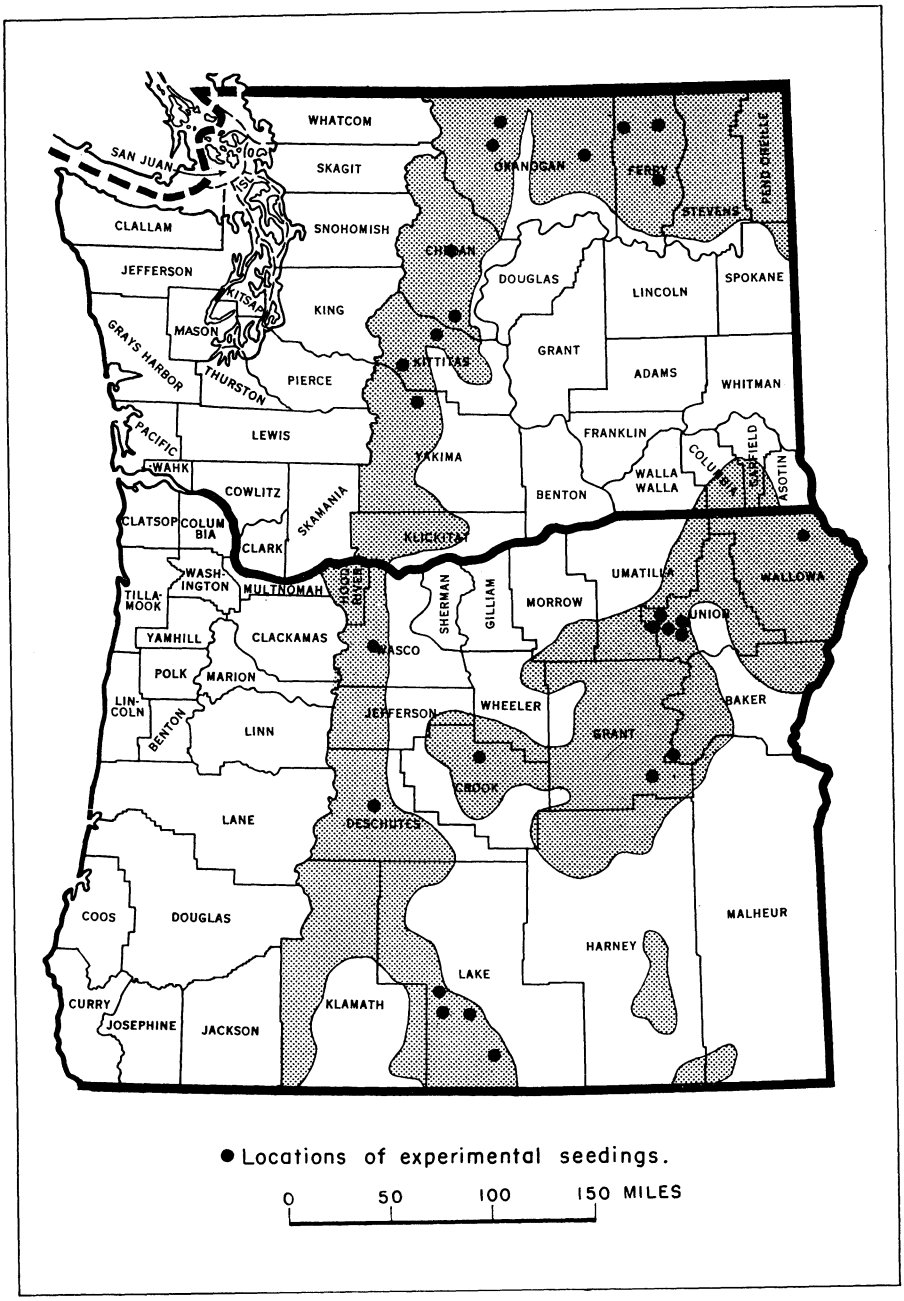

FIGURE 1.—Summer range areas in eastern Oregon and eastern Washington.

To find successful ways for seeding summer ranges, the Forest Service has tested approximately 150 forage species and strains on many experimental areas under numerous conditions and methods of planting. In addition, many other seedings made by ranchers and Federal land administrators have been studied, and information from the Soil Conservation Service and State agricultural experiment stations has been drawn on where pertinent. The results are the basis of recommendations reported in this bulletin.

These recommendations apply specifically to summer rangelands in need of seeding in eastern Oregon and Washington, but the principles may be applicable to similar situations elsewhere. There are conditions, however, for which recommendations are not provided. For example, additional research is needed on how to seed grassland areas with shallow soils in the ponderosa pine zone and subalpine ranges. Also, more information is needed on effects of grass on future stands of trees.

Establishment of seeded grasses in the summer ranges of eastern Oregon and Washington is generally favored by the soils and climate. There are, however, some features that limit the choice of species, methods, and areas on which to seed. The soils, generally of basaltic, granitic, glacial, or sandstone origin, support good stands of seeded grasses, except for some areas of coarse pumice and coarse glacial soil in both States and localized areas of almost pure fine pumicite in eastern Oregon.

Annual precipitation is adequate for many grasses and legumes, ranging from 9 to 14 inches in the sagebrush-grass zone, 13 or 14 to 20 inches in the ponderosa pine zone, and from 20 to as high as 80 inches in the subalpine grasslands. Warm season (April to September) precipitation is generally low with July and August being very dry. Shortage of summer precipitation affects timing and method of seeding. Temperatures are generally below freezing during winter, with prolonged periods of below zero being common, requiring choice of winter hardy species.

Climatic and soil conditions conducive to frost heaving of young plants are common, making choice of species which will withstand frost heaving, methods of planting, and associated practices important considerations in seeding. Limited accessibility of some mountainous seeding areas often influences when and how seeding work can be done. Yet within the limits prescribed by local conditions, most of the 600,000 acres of summer ranges now relatively unproductive can be successfully seeded.

GENERAL GUIDES TO RANGE SEEDING

Well planned and carefully executed range seeding can result in rapid range improvement. Select carefully areas to be seeded, kinds of grasses or legumes, and methods of seeding; and allow for proper grazing after the stand is established. On small or large seeding projects, thorough advance planning and careful observance of the following basic principles will result in more efficient use of seeding equipment and material, and help you meet your goal of establishing and maintaining good stands of grass that best meet range needs.

Choose Sites Carefully

In deciding whether a site should be seeded, the following questions should be asked:

Is seeding actually needed?—Proper management alone will often provide satisfactory improvement where enough desirable forage plants remain. However, the average range site should be seeded if good forage plants cover less than 2 to 4 square feet per 100 square feet of ground surface. On sites with good soil and moisture conditions, such as meadows, seeding may be desirable even where good forage plants cover as much as 5 or 6 square feet per 100 square feet of ground surface. Here the chances are

excellent for quickly increasing forage yields by seeding.

Are proved methods available for the site?—Satisfactory seeding procedures have been developed for many range sites in eastern Oregon and eastern Washington. However, procedures recommended for the general type sometimes are difficult to use because of steep, rocky slopes or other factors. Local range technicians and neighboring ranchers may know of good ways, not treated in this bulletin, for seeding such range areas.

Can the area be grazed properly after seeding?—Protection from livestock and big-game use during establishment, and moderate use once grazing is begun will increase chances for maintenance of good stands.

Select Proper Species, Mixtures, and Rates

Species should be well adapted, provide forage at the time most needed, be able to withstand the expected intensity of grazing, and supply adequate soil cover. Adaptation of species depends mainly on available soil moisture, but temperature, elevation, frost heaving, soil drainage, and fertility can also be important.

Simple mixtures containing not over 3 or 4 different adapted species are generally best. The resulting stands of grass are easier to manage than those which contain many species of widely varying palatabilities or growth habits. In some cases, one grass alone, or one grass with a legume is satisfactory, particularly where range site conditions are uniform.

Where immediate soil stabilization is essential as on burned-over forest land or erodible ground denuded during logging or construction, rapid-developing grasses like timothy and orchardgrass are useful in the mixture. In shady locations, shade-tolerant grasses such as blue wildrye are needed. Species with low fertility requirements such as Topar pubescent wheatgrass are needed where soil depletion is serious and the topsoil is gone.

Drought-tolerant species should be used on sagebrush, bunchgrass, and cheatgrass brome sites within the summer range areas where moisture is limited. Among the species which can grow well with as little as 9 or 10 inches of precipitation are crested wheatgrass [2] and Whitmar beardless wheatgrass. Other grasses like Tualatin oatgrass, Manchar smooth brome, and orchardgrass need 15 or more inches of precipitation. They do not do well on the dry sites and are better adapted and more productive in higher precipitation zones than the drought-tolerant species. Some species such as intermediate wheatgrass will not thrive in sites with poor drainage.

Frost heaving of seedlings and young plants is common throughout much of the summer range area of Oregon and Washington in the fall and early spring, when the soil is unprotected by snow and saturated with moisture, and alternating warm and freezing temperatures occur. Plants are torn loose from the soil and "heaved" upwards by expanding ice crystals. Rootlets are broken and the plants frequently die. In severe cases plants are pushed completely out of the soil. Intense frost-heaving conditions on a site make it necessary to use species which have rapid developing seedlings and deep-growing fibrous roots or underground stems.

Grasses should be similar in seasons of use and palatability to the range plants on adjacent unseeded range, especially where the seeded area is to be grazed along with the unseeded range If livestock prefer the seeded grass, they can kill it out by overuse, and utilize little of the native forage. Whitmar beardless wheatgrass would be a good choice for a grassland area in the ponderosa pine forest range zone because it would be

[2] Most authorities now recognize that what has become known as Standard crested wheatgrass is more properly desert wheatgrass (*Agropyron desertorum*), and Fairway crested wheatgrass the true crested wheatgrass (*A. cristatum*). In this bulletin, however, the name crested wheatgrass refers to Standard crested wheatgrass in line with established usage. A list of the common and scientific names of all plants mentioned occurs at the end of the bulletin.

ready to graze at about the same time of the season as the native bunchgrasses on unseeded range. It also would have about the same palatability to livestock as the native grass.

Species that can withstand heavy grazing are desirable around water holes or other places where livestock congregate. One such species is crested wheatgrass. Although its herbage production is lowered by heavy use, crested wheatgrass is difficult to kill by grazing. Use of species of low palatability on areas where livestock tend to congregate is a good way to impel them elsewhere and thereby encourage proper use over the whole range. Hard fescue and chewings fescue are examples of grasses which have fairly low palatability.

If early forage is desired, grasses should be selected which, in addition to being adapted to the seeding area, will also be ready to graze early in the season. Crested wheatgrass will provide early forage. If good midsummer forage is needed, late-maturing grasses such as intermediate wheatgrass should be seeded to furnish green forage at that time.

Certain strains, varieties, and selections are superior to others of the same species in rate of seedling development, seed production, ease of seeding, disease resistance, or herbage production. For example, Manchar smooth brome has seedlings that are very vigorous and develop faster on summer ranges than other strains of smooth brome. Tualatin oatgrass is recommended over commercial tall oatgrass because it is leafier and the seed is more readily obtainable; Tualatin seed is resistant to shattering.

Recommended forage plants for specific range situations are given in following sections. Additional information on characteristics of grasses can be found in United States Department of Agriculture Miscellaneous Publication 678, Grasses and Legumes for Soil Conservation in the Pacific Northwest.

Enough seed should be planted to produce a full stand of grass, but not so much that the plants will compete with each other to the detriment of all. More pounds per acre are required for large-seeded species such as Bromar mountain brome or Topar pubescent wheatgrass than for small-seeded species like timothy and Highland bentgrass. Fewer seeds per acre are required for species that have strong seedlings or large, mature plants. More seed can be used on meadows than on dry ridgetops because the meadow, which probably has more soil and better moisture conditions, can support a thicker stand of grass.

Since most drills do not have rate settings that fit grasses used in range seeding, they must usually be calibrated. Calibration of drills often results in considerable saving of seed and is good insurance for obtaining the desired seeding rate. The number of seeds per linear foot in the following tabulation will prove helpful in drill calibration:

Species:	*Seeds per linear foot of drill row when seeded at 1 pound per acre* [1] *(number)*
Alfalfa	4.6
Bentgrass, Highland	200.3
Brome, mountain	2.1
Brome, smooth	2.9
Fescue, Alta	5.3
Fescue, chewings	14.1
Fescue, red	14.1
Fescue, hard	13.0
Foxtail, meadow	20.6
Oatgrass, tall	3.0
Orchardgrass	11.2
Redtop	114.6
Timothy	30.3
Wheatgrass, beardless bluebunch	3.1
Wheatgrass, Standard crested	4.0
Wheatgrass, intermediate	2.3
Wheatgrass, pubescent	2.1
Wildrye, blue	3.0

[1] This tabulation applies to rows spaced 12 inches apart; for 6-inch rows divide the numbers by 2.

When using 12-inch row spacing, the correct number of seeds per foot of drill row is found by multiplying the figures given in the tabulation by the desired number of pounds per acre. For example: if intermediate wheatgrass is to be seeded at 8 pounds per acre, multiply 2.3 by 8. The product, 18.4, is the number of seeds needed per foot of drill row. The drill feeds can be adjusted until approximately 18 seeds are fed out

in each row foot. Seeds can be easily counted after running the drill over a piece of old canvas, hard packed soil, or concrete with drag chains lifted. For 6-inch rows the tabulation figures would be divided by 2. Instead of using 2.3, 1.15 would be multiplied by 8. The product, 9.2, is the number of seeds needed per linear foot of drill row when rows are 6 inches apart.

Some drills cannot be adjusted to feed small-seeded species at light rates. One way to overcome this is to mix the seed with rice hulls to get more bulk.[3] The drill feeds can then be opened wide enough during calibration to allow the desired number of seeds to come through.

Selecting seed that has high viability and purity is good business. Seed low in germination may not have vigor to produce strong seedlings. Using seed of high purity minimizes the chance of introducing undesirable weeds.

Seeding rates specified later in this bulletin refer to live, pure seed. To find how many pounds of sack-run seed are needed per acre to obtain the desired live, pure seed rate, multiply the recommended rate, in pounds of live, pure seed per acre by the appropriate conversion factor from table 1. *Example:* A sack of seed is 90 percent pure and has a germination percentage of 85. The conversion factor is 1.31. If 8 pounds of live, pure seed are to be seeded per acre, the 8 is multiplied by 1.31. The product shows that 10.48 pounds of sack-run seed should be planted per acre.

Since seeding rate is important, and some seeds decline rather rapidly in viability, it is advisable to make germination tests of seeds that have been held over from one year to the next. As seed loses viability, more pounds per acre will be needed to provide the desired number of live, pure seed. Tests of germination can be made at State seed laboratories.

Prepare a Good Seedbed

A firm seedbed from which competing vegetation has been removed will favor successful seeding (fig. 2). Where plowing or disking has been done in the early summer, the soil sometimes firms itself before fall seeding time. Cultipacking or rolling can be used to firm the soil if the seedbed is too loose at planting time. If broadcasting is the method of seeding used, loose seedbeds may be desirable

[3] Use of rice hulls is described in Rice Hulls for Seeding, by W. L. Southworth, Soil Conservation 14:280–282. 1949.

TABLE 1.—*Conversion factors for determining number of pounds of sack-run seed to sow per acre* [1]

Purity percent	Percent germination										
	50	55	60	65	70	75	80	85	90	95	100
50	4. 00	3. 64	3. 33	3. 07	2. 86	2. 66	2. 50	2. 35	2. 22	2. 10	2. 00
55	3. 64	3. 30	3. 03	2. 80	2. 59	2. 43	2. 27	2. 14	2. 02	1. 92	1. 82
60	3. 33	3. 03	2. 78	2. 56	2. 38	2. 22	2. 08	1. 96	1. 85	1. 76	1. 67
65	3. 07	2. 80	2. 56	2. 37	2. 20	2. 05	1. 93	1. 81	1. 71	1. 63	1. 54
70	2. 86	2. 59	2. 38	2. 20	2. 04	1. 90	1. 79	1. 68	1. 59	1. 50	1. 43
75	2. 66	2. 43	2. 22	2. 05	1. 90	1. 78	1. 67	1. 57	1. 49	1. 40	1. 33
80	2. 50	2. 27	2. 08	1. 93	1. 79	1. 67	1. 56	1. 47	1. 39	1. 32	1. 25
85	2. 35	2. 14	1. 96	1. 81	1. 68	1. 57	1. 47	1. 38	1. 31	1. 24	1. 18
90	2. 22	2. 02	1. 85	1. 71	1. 59	1. 49	1. 39	1. 31	1. 23	1. 17	1. 11
95	2. 10	1. 92	1. 76	1. 63	1. 50	1. 40	1. 32	1. 24	1. 17	1. 11	1. 05
100	2. 00	1. 82	1. 67	1. 54	1. 43	1. 33	1. 25	1. 18	1. 11	1. 05	1. 00

[1] Source: Figure 1 from Converting Standard Seeding Rates for Grasses to Actual Seeding Rates per Acre, by Joseph F. Pechanec. Research Note 67. Pacific Northwest Forest and Range Experiment Station, U. S. Forest Service, Portland, Oreg., 1950.

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FIGURE 2.—Good seedbed preparation is essential for successful range seeding. This summer range area was thoroughly disked in early summer, disked again in the fall, and then cultipacked before seeding. A firm, weed-free seedbed was the result.

since the seed will be covered as the soil settles.

Cultivation on the contour is desirable to minimize erosion. If the furrows extend up and down the slope and they collect runoff from snowmelt or spring rains, serious erosion can result. Seed can be washed away before it has a chance to germinate.

With the exception of ground denuded by logging, construction of roads, power lines, and pipelines, or accidental fire, every summer range area in eastern Oregon and eastern Washington that needs to be seeded has some type of plant cover. Generally, dense stands of low-value plants like cluster tarweed or California falsehellebore are fully utilizing soil moisture and need to be removed or materially reduced so that seeded plants can become established.

In the reduction of competing vegetation, two generalizations are of value. First, perennial plants ordinarily are most readily destroyed 6 to 8 weeks after growth starts in the spring. With many herbaceous species this time comes just before full bloom when food storage in the plant may be low. Second, most annual plants can be killed by thorough cultivation in the spring as soon as the previous year's seed has germinated, but before the plants have bloomed.

Undesirable, competing vegetation usually can be removed mechanically, chemically, or with fire. While mechanical removal is ordinarily the most expensive, it is relatively sure and has the advantage of preparing a seedbed in the same operation.

Chemical elimination of competing vegetation on the range is relatively new but many undesirable range plants are being controlled. This method is increasing in usefulness as research reveals new chemicals and ways of application. On many sites grass can be drilled directly into the soil without further seedbed

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preparation following chemical elimination of vegetation. However, cultivation may be needed on heavy clay soils to assure seeding success.

Fire can be used in special instances, particularly to destroy big sagebrush. Guides to use of fire in destroying big sagebrush can be found in United States Department of Agriculture Farmers' Bulletin 1948, Sagebrush Burning—Good and Bad. On summer ranges timber and watershed values are generally high, so fire should be used with extreme caution.

Use of insects for plant control is rather limited in application. However, this method is proving effective in controlling common St. Johnswort, especially in California and on large areas infested by dense stands. Two small beetles, *Chrysolina hyperici* and *C. gemellata*, which feed exclusively on foliage of St. Johnswort, are the insects used.

Use Best Practical Planting Procedures

Plant at the Proper Season

Late fall has been found the most practicable planting season on the summer range, even though spring seedings have frequently given better results in experimental tests. Competing plants can be eradicated during the spring or summer as recommended, rains will have firmed the seedbed by late fall, and drills or other seeding equipment can be operated efficiently.

Impassable roads and late spring rains often limit the spring planting period to 2 or 3 weeks. This is usually too short a period to permit adequate planning and conduct of the work, unless only a small acreage is to be seeded. Furthermore, even though some ranges are accessible in the early spring, the soils may be too wet and equipment may bog down or soils may be compacted by tractor wheels. These summer range soils dry out rapidly and, except in the northern part of eastern Washington, summer rains frequently are not great enough to provide seedlings planted in spring or early summer with needed moisture.

Although early fall seedings sometimes yield spectacular success, fall germination of seed is often accompanied by high mortality due to freezing, drought, or frost heaving. Early fall planting is not recommended.

Some species, such as Whitmar beardless wheatgrass, are subject to seedling diseases. If possible, these should be planted in the spring. Legumes do better when planted in the spring because they germinate at low temperatures and, if planted in the fall, are often winterkilled. When legumes are included in a mixture, planting should be done in the spring to favor the legume.

Plant Seed at Proper Depth

All of the grasses and legumes recommended in this bulletin should be planted less than 1 inch deep, since the seedlings generally do not have the strength needed to penetrate more than 1 inch of soil. For maximum emergence, small-seeded species such as timothy and orchardgrass should be planted about one-quarter inch deep. Larger-seeded species, such as Manchar smooth brome and intermediate wheatgrass, do best when seeded at a depth of one-half to three-quarters of an inch.

Plantings made in light, sandy soils should be deeper than those in the heavier, clay soils. Sandy soils dry out more rapidly than do the clay soils and seedling grasses have less time to grow before moisture becomes limiting. In addition, seedlings have less difficulty in emerging through sandy soils which do not pack as tightly as clay soils.

When drilling mixtures containing species of differing seed sizes, plant no deeper than the depth at which the smallest seed should be sown. One way to obtain correct seeding depths is to put the smaller-seeded species in the grass seed attachment of the drill, and lift the spouts out of the furrow openers so the seed is broadcast behind the furrow openers. The larger seeded species can

be put in the grain box and drilled through the furrow openers to the desired depth.

Depth regulators (fig. 3) attached to drill disks are very useful in controlling the depth of seeding. One type consists of an adjustable band which can be easily mounted on a double-disk type of drill or on a single-disk drill with disks spaced 12 inches or more apart. This band prevents the disks from sinking into the soil and planting the seed too deeply.

Distribute Seed Uniformly

To obtain uniform distribution of seed, check drills frequently and make certain that agitators are working and all hoppers are feeding at the desired rate. Where seed is broadcast by airplane, hand, or with a motorized broadcaster, strip markers can be used to prevent overseeding or skipping certain strips. Heavy and light seeds tend to separate when placed together in the drill box and the heavier seeds feed out first. This can be avoided by putting the smaller seeds in the grass-seed attachment and the larger seeds in the grain box.

Uniform distribution of seeds in mixtures can also be obtained by mixing them with rice hulls. Small seeds, such as timothy, are trapped by the concave surfaces of the rice hulls and separation of large and small seed is prevented.

Consider Alternate Row Seeding

Alternate row seeding is a useful method for seeding mixtures of grass and legumes. This technique is strongly

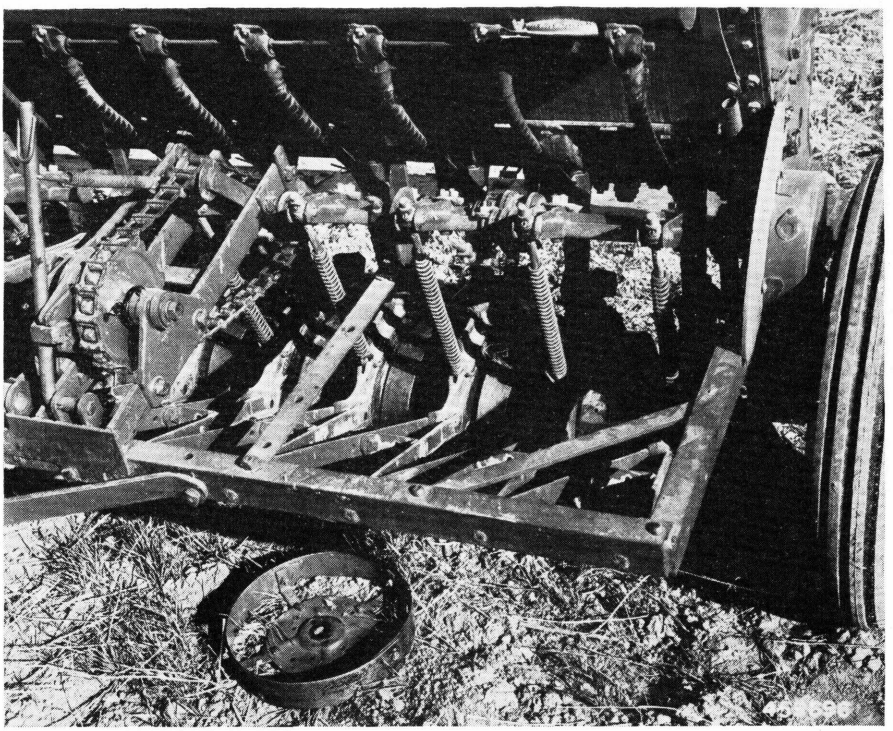

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FIGURE 3.—Adjustable band depth regulators permit shallow seeding of small grass and legume seeds. These regulators can be adjusted for seeding at depths of 1 inch or less. Disks equipped with the depth regulators ride shallowly over soft spots or high spots in which seeds are usually buried too deeply when depth regulators are not used.

recommended because it allows the grass and legume seedlings to make initial growth without severe competition from one another and results in better stands. The grass seed can be placed in the main seed box with alternate feeds closed, while the legume seed is placed in the grass seeder box with the opposite feeds closed. If alternate row plantings must be made through the main seeder box only of a drill equipped with dividers, rice hulls are very useful as a diluent in obtaining a proper rate of seeding for each species.

Inoculate Legumes

Seed of all legumes should be inoculated with the recommended strain of nitrogen-fixing bacteria. Since different strains of inoculant are used for the different legumes, it is advisable to consult county agricultural extension agents, other technicians, or seed dealers before purchasing the inoculant.

Control Rodents and Insects

Large populations of pocket gophers, ground squirrels, mice, and some insects like crickets and grasshoppers sometimes prevent grass stands from succeeding. Where required, control measures should be applied prior to seeding, and again after a seeded stand is established if rodents or insects threaten to damage or destroy it.

The Pacific grass bug (*Irbisia pacificus*), a small leafhopper, has caused serious injury to newly planted grass stands on mountain meadows and subalpine grasslands in central Washington and Oregon. This insect weakens young plants by sucking juices out of the leaves until they are whitish and mottled. Where heavy infestations occur, seeding is not recommended until practical control measures are found. Timothy mite is another insect which sometimes attacks forage plants, but it has not been serious on most summer range seedings.

County agricultural extension agents can provide up-to-date information on control of many rodents and insects.

Graze Seeded Ranges Carefully

New stands of most forage species usually require a minimum of 2 years to become well established. Where moisture conditions prove especially favorable and vigorous stands have been obtained, light grazing sometimes can be permitted in the fall of the second year. Protecting newly planted grass stands from grazing allows the seedlings to become firmly rooted, vigorous, and productive. Such plants are much more effective in preventing reinvasion of undesirable plants, and withstand subsequent grazing better than plants retarded by grazing as seedlings. If adverse weather or unfavorable soil conditions materially delay the maturing of seeded species, deferment of grazing for 3 or 4 years may be necessary.

After grazing is begun, approximately one-half of the current herbage production should be left ungrazed each year to permit plants to store food and maintain vigor. Conservative use is even more important on badly depleted sites to permit return of ample organic matter to the soil. Leaving some seed heads ungrazed will help provide for natural reseeding.

Most ranges requiring seeding have been natural concentration spots for livestock. It is extremely important, therefore, to do everything possible to draw the livestock away from areas of concentration to prevent re-depletion. This may mean a better planned and more concentrated program of riding and herding—placing the cattle where they should be. Water, the strongest single factor in attracting livestock, should be fully developed. A well-thought-out salting plan can be used to help distribute livestock uniformly over the entire range. Fences may be needed to safeguard seeded stands on concentration areas. If properly located, these fences will be useful later for regulating grazing and employing improved practices such as rotation types of grazing.

SPECIFIC GUIDES FOR SEEDING RANGE TYPES

Each summer range type presents problems in seeding which are peculiar to that type. As a consequence, separate seeding prescriptions are necessary. In the following sections, recommendations are given for seeding sagebrush-grass ranges, grasslands in the ponderosa pine zone, mountain meadows, and subalpine grasslands. Included also, are recommendations for seeding areas disturbed by logging and construction and by accidental fires.

Seeding the Sagebrush-Grass Type

Good forage plants like bearded bluebunch wheatgrass, Idaho fescue, prairie junegrass, and Nevada bluegrass have been replaced on many sagebrush-grass summer ranges by less valuable sagebrush, rabbitbrush, Sandberg bluegrass, and cheatgrass brome or cheatgrass, as it is sometimes called (fig. 4). Species and methods are available for seeding that can result in greatly increased forage production on these areas at reasonable cost. However, the sagebrush-grass type is the driest of the summer range types and species chosen must be able to grow with only 9 to 14 inches of annual precipitation.

Costs will vary with size of seeding, kind of equipment, species, and other factors. In Oregon, based on 1949 and 1950 prices, estimated costs incurred by two ranchers were $4.81 per acre (cleared by burning; no fencing) and about $15 per acre (mechanical clearing; electric fence). Additional information on costs for seeding sagebrush-grass ranges can be found in Oregon Agricultural Experiment Station Circular of Information 497, Cost Guides for Range Reseeding. While

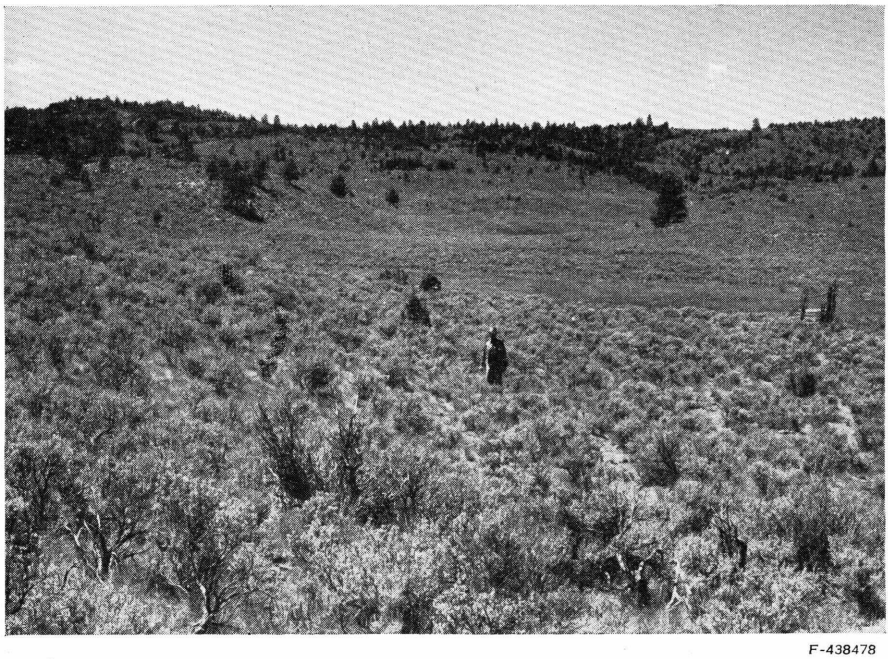

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FIGURE 4.—Typical sagebrush-grass summer range just below and intermingled with the ponderosa pine zone. Idaho fescue, bearded bluebunch wheatgrass, prairie junegrass, and Nevada bluegrass have been largeley replaced by dense stands of sagebrush, rabbitbrush, Sandberg bluegrass, and cheatgrass brome. Such ranges should be seeded.

these guides pertain to seeding on sagebrush-grass rangelands, the figures will prove useful in arriving at cost estimates for seeding other range areas.

What Areas to Seed

Seed first areas where big sagebrush is growing 2 feet or more tall in 12 inches or more of soil relatively free from rocks. Large, vigorous sagebrush plants usually indicate good soil and favorable growing conditions. Areas where low sagebrush grows do not have a high potential for producing forage, although seeding may be justified if forage is urgently needed.

Where rabbitbrush is abundant, seeding can be successful but special care is needed to eliminate the rabbitbrush because it is very difficult to kill. Rabbitbrush sprouts readily after burning or shallow plowing.

Ordinarily, sagebrush lands need not be seeded if desirable perennial grasses, such as bluebunch wheatgrass, Idaho fescue, and prairie junegrass, cover more than 2 square feet per 100 square feet of ground. Through good grazing practices these ranges will recover naturally within a reasonable time. Killing of competing brush by spraying or beating will speed recovery of native grasses on these ranges.

What Species to Seed

As a group, the wheatgrasses have proved best for seeding in the sagebrush-grass type on summer ranges. In south and central Oregon plantings, Topar pubescent, intermediate, and crested wheatgrasses (fig. 5) were consistently among the better species. They produced good stands and retarded invasion by cheatgrass brome. Topar pubescent wheatgrass, which produces underground rootstalks, totally eliminated cheatgrass brome on study plots in the sagebrush type. It prevented invasion by young plants of sagebrush and rabbitbrush,

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FIGURE 5.—This excellent stand of intermediate and crested wheatgrasses in its second season of growth was planted in late fall on sagebrush-grass range in southern Oregon.

while there was some invasion of these undesirable species on plots of 14 other species. Although Whitmar beardless wheatgrass did not show up well in all of these trials, it is a drought-resistant, long-lived bunchgrass which has been proved adapted in other trials. Recommended species and seeding rates per acre are as follows:

Annual precipitation and kind of soil	*Species*	*Live, pure seed per acre*[1] *(pounds)*
9–15 inches.....	Crested wheatgrass.	6
	or	
	Whitmar beardless wheatgrass.	8
12 or more inches:		
Poor soil.....	Crested wheatgrass.	6
	or	
	Topar pubescent wheatgrass.	10
	or	
	Whitmar beardless wheatgrass.	8
Good, well-drained soil.	Intermediate wheatgrass.	9
	or	
	Topar pubescent wheatgrass.	10
15 or more inches; good, well-drained soil.	Intermediate wheatgrass.	10

[1] For methods of computing pounds of live, pure seed, see page 6.

Choice between species for a specific combination of precipitation and soil conditions depends principally upon expected time of grazing. For early forage, crested wheatgrass is a good choice. It begins spring growth early and often will provide good forage from about May 15 to July 1 on the summer range sagebrush-grass type. Whitmar beardless wheatgrass begins its spring growth about 2 to 3 weeks later than crested and can be grazed from about June 1 to July 15. Topar pubescent and intermediate wheatgrasses start spring growth about the same time as crested but both are late-maturing grasses which will extend the good grazing period into August. By planting these grasses in separate fields where adapted, the period when palatable green forage is available can be extended from about May 15 to the middle of August, or later in years of high summer rainfall.

When and How to Seed

Planting should be done as late in the fall as possible, preferably during the month of October, to lessen the dangers of frost heaving. Drilling with either double- or single-disk drills is recommended for the sagebrush-grass summer ranges. Broadcast seeding generally does not give successful results because of the low precipitation.

Seedbeds can be prepared with several kinds of equipment, depending upon the amount of rock in the soil and on the kind of competing vegetation to be eradicated. Use of this equipment is discussed in the following paragraphs which describe how to eliminate the principal competing plants: Big sagebrush, low sagebrush, rabbitbrush, and cheatgrass brome.

Big sagebrush.—Plowing with one-way disk plow (wheatland type), heavy offset disk, or brushland plow (fig. 6) to a depth of 2 to 4 inches is one of the best methods for killing big sagebrush. The one-way disk plow and heavy offset disk are adapted to areas of nearly rock-free soil while the brushland plow is especially adapted to rough, rocky ground. For compact clay soils that are very hard when dry, an extra heavy offset disk weighing 500 pounds or more per foot of cutting width, with disks from 28 to 32 inches in diameter, is needed. Because of its weight this disk needs an 80-horsepower tractor for a 10-foot model on fairly level ground.

Plowing generally should be done between May 15 and September 1, before big sagebrush seed is ripe and begins to scatter. Plowing early in the summer is best for several reasons: The kill of sagebrush is likely to be higher when the soil is moist; the implements will work better and easier; and the soil will settle by fall to provide a firmer seedbed. Early summer plowing also will give grass seedlings a better start because the removal of sagebrush early in the season conserves soil moisture and causes a slight increase in available nitrogen.

Burning is an inexpensive and effective method for killing big sagebrush. It can

F-453180

FIGURE 6.—Seedbeds can be prepared on rough sagebrush lands with a brushland plow. The disks are mounted in pairs and are held in the ground by spring tension. If a solid obstruction such as a rock or heavy root is met, the obstructed pair of disks raises up while the others continue to work.

be successfully done on areas having enough sagebrush or other undercover to carry the fire, and where the fire can be controlled by plowed firelines, streams, roads, or other firebreaks. Compact tracts of 500 or more acres are desirable. On smaller areas, per acre costs of fireline construction and fire control may be excessively high. Fireline construction is a major cost item in sagebrush burning and compact areas will result in the smallest possible amount of fireline.

Ordinarily, sagebrush should be burned between August 1 and September 10 when it is just starting to bloom. On areas which have abundant cheatgrass brome, earlier burning is desirable to kill the cheatgrass before its seed ripens.

Spraying big sagebrush with herbicides has resulted in satisfactory kills in California, Wyoming, Colorado, and southeastern Oregon. One or two pounds of either the isopropyl ester or the butyl ester of 2,4-D or 1 pound of 2,4,5-T in 5 to 20 gallons of water or 3 to 5 gallons of diesel oil per acre is recommended. This can be applied by airplane or ground spray, whichever is least expensive, from about May 10 to July 1 when the sagebrush is actively growing. Sodium or amine salts of 2,4-D are not recommended for spraying big sagebrush.

Spraying of big sagebrush and other shrubby species has one disadvantage for seeding. Although the plants are killed by the chemicals, the woody stems remain

and seriously hamper the use of drills. This may mean that the grass seed must be broadcast, not a reliable method of seeding in the sagebrush-grass type on summer range areas.

Other methods often used for control of big sagebrush are railing, harrowing with the pipe harrow, beating, and grubbing. Detailed information on all methods can be found in United States Department of Agriculture Farmers' Bulletin 2072, Controlling Sagebrush on Range Lands.

Removal of sagebrush or other shrubby plants by spraying or beating sometimes will result in needed range improvement without seeding on ranges where one or more plants of good forage grasses grow per square yard. When competition from brush is removed, and the area is properly grazed, good forage grasses frequently increase in vigor and number.

Low sagebrush.—The same general procedures described for killing big sagebrush will apply to low sagebrush, except for burning. Burning is not a satisfactory method of controlling low sagebrush because the sparse stands in which it grows usually will not carry the fire.

Low sagebrush blooms and matures seed almost 3 weeks earlier than big sagebrush. Plowing should, therefore, be completed by mid-August on sites supporting low sagebrush.

Rabbitbrush.—Rabbitbrush is commonly associated with sagebrush but frequently grows in dense stands with weeds and a few grasses. Because it sprouts vigorously from the roots and stem base, plowing 5 to 7 inches deep to cut the roots below the crown is required for satisfactory rabbitbrush control. Plowing in June or early July, when the plants are growing rapidly, is most effective. Burning is not a satisfactory method of control because rabbitbrush generally sprouts abundantly following a fire. Promising results with herbicides are beginning to appear in a few experiments, but herbicides cannot yet be recommended for rabbitbrush control.

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Cheatgrass brome.—Satisfactory stands of seeded species are rarely secured without control of cheatgrass brome. This annual grass occurs widely on summer ranges where it has invaded depleted grasslands and areas disturbed by logging and road construction. Cheatgrass brome can be controlled by cultivation or burning.

Where soils are sufficiently deep and rock-free, thorough cultivation either with one-way disk or heavy offset disk plows produces satisfactory kills of cheatgrass brome. The brushland plow can be used on rocky or uneven ground. Cultivation or plowing must be done as early in the spring or summer as possible, and before cheatgrass seedheads fully emerge from the leaf sheath.

Burning will control cheatgrass brome if done in the spring when cheatgrass is in the "red" stage or before seeds have a chance to mature and drop to the ground. Fires set for burning cheatgrass must be carefully handled, since they can easily get out of control.

In central Washington studies, spring plowing was very effective in reducing numbers of cheatgrass brome plants. An average of only 10 per square foot grew on the plowed plots the year following plowing while 111 per square foot grew on undisturbed plots. Spring burning when cheatgrass was in the "red" stage was the next most effective treatment, resulting in only 15 cheatgrass plants per square foot the following year . Summer and fall burning were not effective in reducing numbers of cheatgrass plants.

Records taken on crested and intermediate wheatgrass, 5 and 6 years after they were planted, showed very clearly that cheatgrass brome hindered their establishment. Practically no crested and intermediate wheatgrass grew where they were seeded into undisturbed cheatgrass. Good to medium quality stands of crested and intermediate wheatgrass grew where cheatgrass was controlled by plowing and burning in the "red" stage.

Seeding Grasslands in the Pine Zone

Most of the grasslands in the pine zone supported stands of good bunchgrasses at one time, but many now support plants of low forage value such as Sandberg bluegrass, bottlebrush squirreltail, curly-cup gumweed, cheatgrass brome, cluster tarweed, and St. Johnswort. Many of these areas can once again be good forage producers through successful seeding.

What Grasslands to Seed

Grasslands of the pine zone have a wide range of soil conditions. Some areas have only 3 to 4 inches of soil, while others may have several feet of rich, highly productive soil. The parklike areas of deep, fertile soil offer the greatest opportunities for increasing forage production. Expected forage production from the shallow-soiled areas is not high, but many of these are important parts of watersheds and need to be seeded for watershed improvement.

Areas having 12 inches or more of soil should be seeded first. However, the existing vegetative cover should not be disturbed or seeding attempted if there is already a sizable remnant of desirable perennial grasses. When desirable perennials cover 3 square feet or more per 100 square feet of ground surface, good grazing practices probably will restore the range so that seeding will not be necessary.

Eroded grasslands with shallow soils, generally found along rocky ridgetops or steep, south slopes, are difficult to seed. Cluster tarweed, or gumweed intermixed with bottlebrush squirreltail, rush pussytoes, and Sandberg bluegrass, make up the principal vegetation (fig. 7). The soils contain very little organic matter and lack well-defined structure; the surface bakes hard following rains or becomes powdery if disturbed during dry periods.

What to Seed in Grasslands

Numerous small trials and large scale plantings have pointed out species and mixtures of species that can be used in the grasslands of the pine zone. Recommended species and mixtures in the following tabulation are grouped according to depth of soil on the area to be seeded and amount of annual precipitation. Choice between mixtures in any one group depends on such factors as availability of seed, personal preference, intensity of grazing expected, or how quickly good soil cover is desired.

	Species and mixtures for pine zone grasslands	*Live, pure seed per acre (pounds)*
Deep soil:		
13–15 inches precipitation.	Crested wheatgrass.	6
	or	
	Hard fescue.....	3
	+Topar pubescent wheatgrass.	7
	or	
	Topar pubescent wheatgrass.	10
	or	
	Whitmar beardless wheatgrass.	8
15 inches or more precipitation.	Intermediate wheatgrass.	10
	or	
	Ladak or Nomad creeping alfalfa.	2
	+ intermediate wheatgrass.	8
	or	
	Manchar smooth brome.	6
	+ Ladak or Nomad creeping alfalfa.	2
	or	
	Orchardgrass.....	2
	+ intermediate wheatgrass.	5
	+ timothy.....	1
	or	
	Tualatin oatgrass...	4
	+ orchardgrass	4
Shallow soil:		
13–15 inches precipitation.	Crested wheatgrass.	6
	or	
	Hard fescue.....	6
15 inches or more precipitation.	Hard fescue.....	3
	+Topar pubescent wheatgrass.	7
	or	
	Timothy.....	1
	+ Topar pubescent wheatgrass.	8
	or	
	Topar pubescent wheatgrass.	10

Four of the recommended grasses produced 1,000 to 1,600 pounds of air-dry herbage per acre in 1951, 5 and 6 years after planting on grasslands with deep soils in central Washington. This plant-

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FIGURE 7.—This depleted grassland area with shallow soil has practically no desirable forage plants. Such areas are often very difficult to seed successfully because of poor growing conditions and frost heaving of young plants.

ing site was at 3,000 feet elevation and received about 14 inches of precipitation. The highest herbage yield of 1,600 pounds was made by intermediate wheatgrass, but Tualatin oatgrass yielded 1,200 pounds; Topar pubescent wheatgrass, 1,100 pounds; and Manchar smooth brome, 1,000 pounds. All of these grasses successfully prevented reinvasion of cheatgrass brome and other undesirable weedy plants.

Tualatin oatgrass is a high forage producer, is very palatable, reseeds itself well, and has withstood heavy fall grazing. It can be weakened by continued heavy grazing during the growing season. Tualatin has an upright, bunch-type growth habit which permits livestock to eat a high percentage of its foliage. Intermediate and Topar pubescent wheatgrasses and Manchar smooth brome, though also palatable, have underground rootstalks and are not so susceptible to damage from heavy grazing.

Orchardgrass produced only 750 pounds in these trials, but its yields have been higher in other plantings and it is recommended for areas with good, well-drained soil and receiving more than 15 inches precipitation. Hard fescue produces only a moderate amount of forage, but it has a strong root system which makes it very effective in stabilizing soil.

Timothy produces forage quickly on grasslands in the pine zone and at the same time provides good soil cover essential to control of erosion. Because it is a short-lived plant, it should be planted with long-lived grasses that will provide forage after the timothy dies out.

Both crested and Whitmar beardless wheatgrasses are useful for grasslands in drier parts of the pine zone. While both are drought resistant, Whitmar has outyielded crested during years of below normal precipitation.

The better grassland areas in the pine zone can be successfully seeded to alfalfa. On one area where annual precipitation was about 14.5 inches, Nomad creeping alfalfa and intermediate wheatgrass were spring planted in alternate rows. Total air-dry herbage yield was 4,175 pounds per acre in the third growing season (fig. 8). Before this area was planted, it was producing only western yarrow, Douglas knotweed, and other undesirable forage plants.

While the choice of species is fairly large for seeding grassland areas in the pine zone that have deep soils, only a small number of species are usable on the shallow-soiled grasslands.

In one trial, 70 species and strains were planted in the fall of 1945 on the Starkey Experimental Forest and Range in northeastern Oregon at 4,500 feet elevation. Soils on the planting area are shallow and rocky and have poor structure. In the spring of 1946, 40 percent of the stands rated good or better, but in the spring of 1947 only 7 percent of the original plantings rated good or better. Most plantings continued to decline, until in 1953 only Topar pubescent wheatgrass, hard fescue, and timothy still survived. Frost heaving was responsible for most of the mortality in this trial.

In other trials on shallow-soiled grassland areas in the pine zone, timothy and Topar pubescent wheatgrass were among the best species. Although Primar slender wheatgrass, orchardgrass, Tualatin oatgrass, and Manchar smooth brome made fair stands, their success was not good enough to justify recommending them for planting on shallow-soiled areas.

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FIGURE 8.—This 3-year-old stand of intermediate wheatgrass and alfalfa yielded 4,175 pounds of herbage per acre on a grassland range site near Conconully, Wash., in 1953.

When and How to Seed Grasslands

The best procedure is to cultivate as early in the spring as is practicable and plant the grass seed immediately, especially when rains are not too heavy and areas are accessible. If spring seeding is not practicable, the seedbed should be plowed or thoroughly disked as early in the spring as possible, and seeded sometime between October 1 and November 15; the later, the better.

Grasslands with moderate to deep soils and little rock can be effectively cultivated with a heavy offset disk or one-way disk plow. For rocky areas the Rockland tiller (fig. 9), developed by the U. S. Forest Service, is recommended.

Seed should be drilled on most grasslands. Standard grain drills of single-disk, double-disk, or deep-furrow type can be successfully used on areas with deep soil and no surface rock. The deep-furrow drill does not work too well where the soil is rocky. For rough terrain, or rocky grassland areas where excessive equipment breakage would occur, hand or motorized broadcast seeders are preferable to drills.

Frost heaving is particularly troublesome in the pine zone on grasslands with shallow soils. However, preliminary studies have shown that a protective mulch of sawdust or woodchips is beneficial in reducing frost heaving of young plants.

In one test Topar pubescent wheatgrass, timothy, and hard fescue were planted on a shallow-soiled grass ridge in October 1951. Sheep manure, sawdust, and 300 pounds of nitrogen per acre were applied individually to some plots while on other plots no fertilizer or mulch was used. In 1953, the best stands of grass were found where sawdust had been applied. Mulching reduced fluctuations in soil temperature, relieving conditions favorable to frost heaving, and helped retain

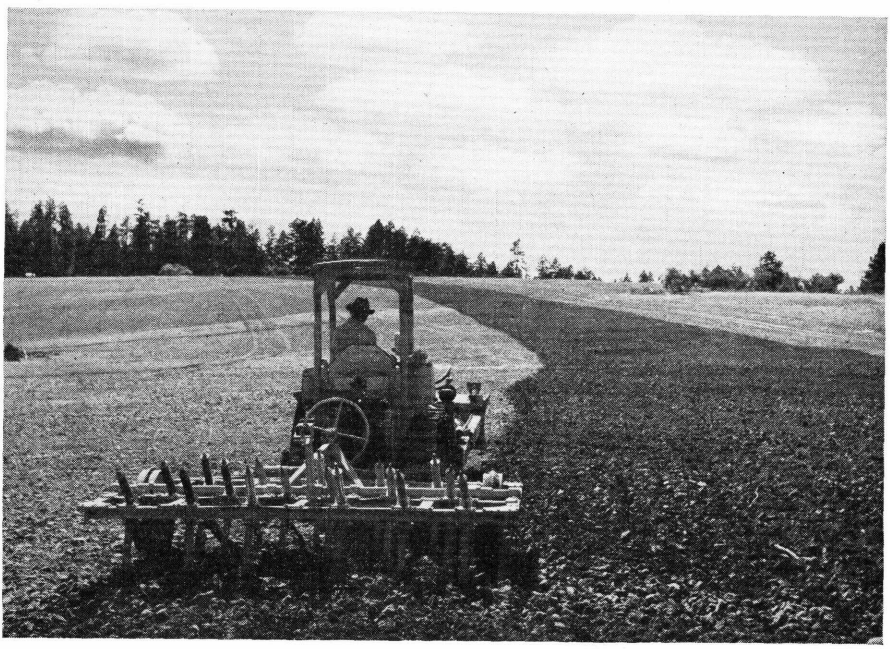

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FIGURE 9.—The Rockland tiller does a good job preparing seedbeds on shallow-soiled, rocky grassland sites. The tiller weighs about 3,000 pounds and each shovel-arm is mounted to trip independently when caught on rocks or roots.

soil moisture longer. This resulted in more grass seedlings than where no mulch was used.

Another test was made using no mulch, and a woodchip mulch one-half inch deep and one-inch deep both with and without nitrogen. This study showed that mulching alone was not as effective as a combination of mulch and supplemental nitrogen. The woodchip mulch aided in reducing amount of frost heaving while the added nitrogen offset nitrogen depletion as the woodchips decayed and stimulated the plants to greater growth and better utilization of the available moisture.

The addition of mulches and fertilizers is expensive, but these studies point the way to developing new techniques in range seeding.

Cluster tarweed and St. Johnswort, two of the most common undesirable plants growing on grassland areas needing seeding, can be eliminated if proper methods are used.

Where tarweed is abundant the soil should be cultivated when the tarweed is 2 inches tall. It is a prolific seed producer and a few scattered plants left will provide enough seed to start an undesirably thick stand of tarweed the following spring.

The Rockland tiller is perhaps the best implement for eradicating tarweed on shallow-soiled areas. In experimental trials it has done a good job in one trip over. A tractor-mounted hydraulic tiller, a springtooth harrow, or a pipe harrow will also give satisfactory kills if the area is cultivated twice or more. Spraying with as little as one-half to three-fourths pound of 2,4-D, either amine salt or ester base, per acre has proved effective in killing tarweed in the Intermountain West.

St. Johnswort, an aggressive plant which spreads both by rhizomes and seed, is difficult to eradicate. Ineffective control may result in poor stands of seeded grass through intense competition. If seeding is planned where St. Johnswort is abundant, the soil should be cultivated thoroughly, before St. Johnswort starts to bloom, for at least 2 successive years. Seeding should be done in the fall of the second year.

Seeding Mountain Meadows

Seeding of mountain meadows where needed can be one of the most profitable seeding undertakings on the summer range. Meadows can yield large amounts of herbage in seeded forage plants, especially where they have not been seriously eroded.

What Meadows to Seed

Most mountain meadows in a deteriorated condition should be seeded except where more than 5 or 6 square feet per 100 square feet of ground is covered with desirable vegetation like tufted hairgrass or thin bentgrass. Such areas might be improved through good grazing practices.

Careful attention must be given to condition of the meadow when selecting species to seed. Some meadows may have simply lost their desirable vegetation without serious loss of soil (fig. 10). These areas can be seeded with the species and mixtures recommended for meadows. Other meadows may have been cut by gullies which have lowered the water table (fig. 11); others may have lost all or most of their topsoil, leaving a rather unproductive, gravelly soil. Meadows which have been gullied and drained or severely eroded cannot be treated as meadows but must be handled as grasslands unless the water table can be raised.

What to Seed on Meadows

Tests of nearly 150 species and strains in mountain meadow areas of Washington and Oregon have shown species adapted to one or more of the wide range of conditions. Among these, a dozen have proved to be valuable in several kinds of meadow sites.

For wet meadows not drained by gullies and with topsoil present, Alta fescue at 8 pounds of live, pure seed per acre, or meadow foxtail at 6 pounds per acre can be used. If the meadow is not drained by gullies but the top soil is eroded, Alta

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FIGURE 10.—This mountain meadow is potentially highly productive, although it now supports few or no desirable forage plants and is covered with whiteface Fendler waterleaf (center) and California falsehellebore (right). Such meadows can be planted with species recommended for meadows after the competing vegetation is controlled.

F-232664

FIGURE 11.—The deep gulley has lowered the water table on this mountain meadow and the former wet meadow conditions no longer exist. Sagebrush and other less desirable forage plants are abundant. Such meadows should be seeded with species recommended for grasslands unless a high water table can be re-established by means of dams or water bars.

fescue is recommended. Alta fescue does well on alkaline sites. Both species can withstand flooding and heavy grazing and are high forage producers, although meadow foxtail is much more palatable to livestock. Meadow foxtail is slow to start and may take 3 to 4 years to reach a full stand.

Where shallow gullies have lowered the water table a foot or two, a mixture of Manchar smooth brome at 5 pounds, plus orchardgrass at 3 pounds, plus timothy at 1 pound per acre can be used.

For meadows drained by deep gullies or where topsoil is severely eroded, the species and mixtures listed for grasslands should be used. Since most mountain meadows receive 15 or more inches of precipitation the choice is narrowed down to the mixtures recommended for that amount of precipitation.

Choice between mixtures for a particular set of meadow conditions depends upon personal preference and to some extent on how the seeded stand is to be used or purpose of the seeding. For example, intermediate wheatgrass plus Ladak or Nomad alfalfa could be chosen where grazing and some hay production are the seeding goals. Where a quick cover is needed, a mixture containing timothy would be desirable.

While many legumes have been tested for adaptability to mountain meadows, very few successes have been obtained. Rodents have been responsible for killing out small experimental seedings of legumes before they were established and before their adaptability could be fully studied. One legume which has resisted rodent damage and has done well in experimental seedings is perennial vetch. This legume, however, is not commercially available.

Nitrogen fertilizer may be helpful in increasing production of established seeded stands on meadows. Surface applications of 90, 60, and 30 pounds per acre of nitrogen on a 5-year-old stand of crested, intermediate, and Topar pubescent wheatgrasses increased forage production in the year of application (fig. 12) in one Oregon study. The site was a badly depleted meadow with topsoil gone and a gravelly subsoil exposed. Crested wheatgrass, which showed the greatest percentage increase in yield, had very poor vigor prior to application of the nitrogen. This probably accounted for its high percentage increase. Crested wheatgrass is not generally recommended for seeding on mountain meadows but it has done fairly well on some dry, poor quality meadow sites.

When and How to Seed Meadows

Late fall seeding is preferred, although successful results can be obtained from spring seeding on mountain meadows. By the time most meadows are dry enough in the spring for seeding equipment to be used, the period of good spring rainfall is generally over. Soils dry out quickly and, without adequate moisture, poor stands often result.

Several kinds of equipment are satisfactory for preparing seedbeds on mountain meadows. Moldboard plows or heavy duty offset disk plows can be used. Both of these implements require more power than lighter equipment does but they will do a good job. A 45-horsepower tractor is needed for a 10-foot model of heavy duty offset disk plow on fairly level ground, and a 70-horsepower tractor for a 14-foot model. Where soils are not hard and compact one-way disk plows or the Brushland plow can be used.

Seed should be drilled to assure proper coverage and even distribution. Ordinary single-disk or double-disk grain drills are satisfactory. Rows can be spaced from 6 to 12 inches apart.

Severely depleted meadows with topsoil gone and gullies present may support abundant annual weeds like Douglas knotweed and cluster tarweed. These weeds can be controlled by thorough cultivation in the spring as soon as the soil is dry enough to work. On depleted meadows which still retain their topsoil, common plants are wyethia, silver sagebrush, California falsehellebore, and

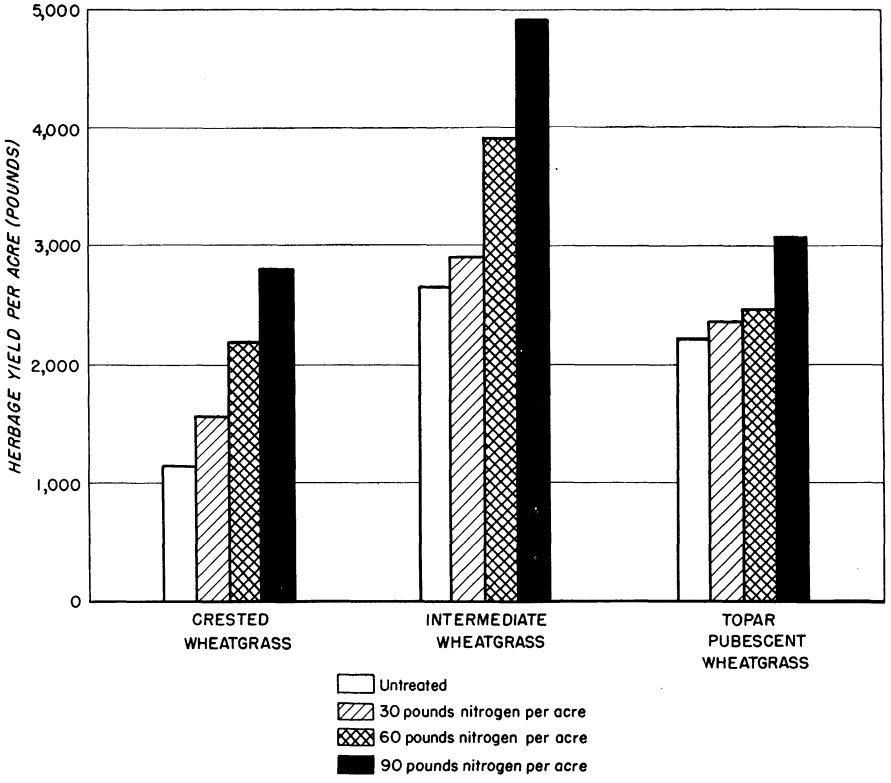

FIGURE 12.—Green weight herbage yield per acre for three wheatgrasses on fertilized and unfertilized land.

whiteface Fendler waterleaf. All of these are aggressive, tenacious plants. Some possible ways for controlling them follow.

Wyethia.—Mulesears wyethia and whitehead wyethia, both of which are coarse, perennial weeds with large basal leaves and thick woody taproots, are generally found in meadows of heavy soil and poor drainage. Although no experimental work on controlling wyethia has been done in Oregon or Washington, workers in eastern Idaho found deep moldboard plowing to be the only effective mechanical method of control. Where treated areas were seeded, good stands of grass resulted. Moldboard plowing is expensive, however, and can be done only in accessible areas with deep, rock-free soils. The offset disk and one-way disk plow were not effective; they cut the wyethia roots, but plants sprouted from both top and bottom parts of the severed roots.

Successful control of wyethia by spraying with 2,4-D has been reported in Idaho and Montana. Numbers of wyethia plants were reduced 81 percent with a 2-pound-per-acre application of the ethyl ester of 2,4-D made between the first-bloom and half-bloom stages in the Idaho work. Spraying with isopropyl ester of 2,4-D at concentrations of 6,000 parts per million gave almost complete control in Montana.

Silver sagebrush.—This sagebrush occurs in limited tracts in meadows where there is poor drainage or standing water during part of the spring. It is more difficult to control than low and big sagebrush because it sprouts readily from the

roots. Plowing with heavy offset disk plows as soon as the soil is dry enough in the spring is most effective in killing silver sagebrush, especially if the areas can be plowed in 2 consecutive years. Plowing in summer or fall is usually not satisfactory. Because of the sprouting habit of silver sagebrush, burning is of no value.

Preliminary results from California studies indicate that spraying with 2,4–D is effective in killing silver sagebrush. When butoxyethanol ester of 2,4–D was applied at the rate of 1 pound per acre, 91 percent of the silver sagebrush was killed.

California falsehellebore.—This large, fleshy-rooted perennial weed grows mainly on meadows, but occasionally it occurs in open ponderosa pine and ponderosa pine-Douglas-fir timber stands. It is usually indicative of poor drainage and soils that are heavy and compact.

Where soils are sufficiently free from rock, moldboard plowing to 6 or 8 inches, as soon as the soil is dry enough, has been effective and is recommended for killing falsehellebore.

Spraying falsehellebore with isopropyl ester of 2,4–D has given successful control (fig. 13). In cooperative studies between Washington State College and the U. S. Forest Service in central Washington, plots were sprayed with 4 pounds of 2,4–D acid equivalent per acre in 1950,

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FIGURE 13.—California falsehellebore frequently prevents successful seeding of mountain meadows. Spraying with 4 pounds of isopropyl ester of 2,4–D per acre in each of two consecutive years, almost completely eradicated the falsehellebore on this mountain meadow in Washington. Treated area is in the foreground.

and again in 1951. In 1952, density of the falsehellebore on the sprayed plots was only 6 percent of the density before spraying (fig. 14). Treatment with 2 pounds of 2,4–D also resulted in large reductions. Treatment with polybor and polybor chlorate was not effective.

Whiteface Fendler waterleaf.—Whiteface Fendler waterleaf is a lush weed which grows densely on depleted meadows and adjacent hillsides in central Washington. Plowing in the early summer with a one-way disk plow has proved fairly effective in controlling this competitor. Spraying with isopropyl ester of 2,4–D at 2 and 4 pounds per acre in 2 successive years has not given satisfactory results, but one application of polybor chlorate at 320 pounds per acre resulted in significant reductions in ground cover.

Seeding Subalpine Grasslands

Subalpine grasslands, which make up about 5 percent of the summer range area of eastern Oregon and eastern Washington, have a high potential grazing capacity. They provide summer grazing for sheep, cattle, and big game, but many are even more important for their high value as watersheds.

Soils are sedimentary, glacial, granitic, or basaltic in origin, loose, and highly erodible. Vegetation on subalpine ranges in good condition is dominated by green fescue, a highly palatable bunchgrass,

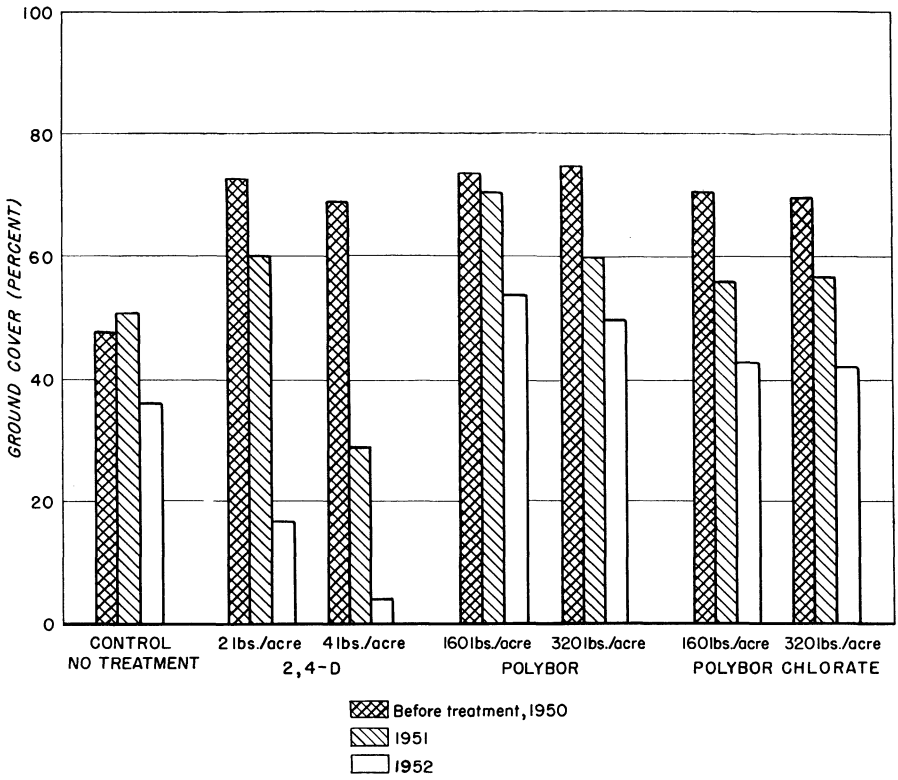

FIGURE 14.—Percent ground cover of California falsehellebore was greatly reduced by spraying with 2,4–D in 1950 and again in 1951. One application of polybor and polybor chlorate in 1950 did not give reductions great enough to be of value in controlling falsehellebore competition for seeding.

with occasional plants of needlegrasses, bottlebrush squirreltail, sedges, lupine, western yarrow, penstemon, and eriogonums.

As these ranges deteriorate, the green fescue cover breaks up, subalpine needlegrass and weeds increase, and soil erosion becomes conspicuous. Many subalpine ranges are now in this condition and need to be improved. Where one or more plants of green fescue and subalpine needlegrass remain per square yard, the range will recover if protected or lightly used. Seeding is usually necessary on subalpine range having few desirable perennials (fig. 15).

What to Seed

Plantings of 18 grasses and legumes made in the spring of 1953 at 6,000 feet elevation in northern Washington yielded good to excellent seedling stands of 15 species. The seedbed was disked in the fall, redisked the following spring because of poor kill of weeds, and then cultipacked. The grasses and legumes were seeded through a single-disk drill and cultipacked after drilling.

By the end of the second growing season the more promising grasses were timothy, orchardgrass, Bromar mountain brome, and Topar pubescent wheatgrass. Nomad creeping alfalfa had done well, although it had been damaged by deer grazing and gophers. Species for seeding depleted subalpine grassland ranges cannot be generally recommended from this one study. However, the excellent stands of these 5 species point strongly toward their use.

When and How to Seed

Information on season and method of planting, as well as species, is limited. For those areas accessible before June 15, spring seeding is suggested. Where spring seeding cannot be done, the seedbed should be cultivated as early as possible

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FIGURE 15.—This subalpine grassland range needs seeding for increased forage production and soil stabilization.

to kill weedy competition and the grass seeded in September or October. Although seed should be drilled wherever possible, broadcasting followed by harrowing or cultipacking may also be tried since moisture conditions generally are favorable in subalpine areas.

Where soils are deep, the seedbed can be prepared with one-way disk plows or heavy offset disks. On shallow-soiled subalpine grasslands, the Rockland tiller can be used.

Seeding Areas Disturbed by Logging and Construction

Loss of vegetative cover due to logging and construction is common on forests and rangelands in eastern Oregon and eastern Washington. Each year about 270,000 acres are logged, mostly by crawler-type tractors or other heavy equipment, and the vegetation is destroyed on 10 to 30 or more percent of the ground surface. Studies have shown that vegetation covers the disturbed ground four years after logging except on areas such as landings and heavily used skidroads where the soil has been compacted. This vegetation consists mainly of undesirable, aggressive species such as western yarrow, heartleaf arnica, thistle, cheatgrass brome, and St. Johnswort. This is also true where the laying of pipelines and the clearing of trees and shrubs from powerline rights-of-way destroy the understory of grasses and other plants (fig. 16).

Seeding grass on these disturbed areas can recover lost grazing capacity, and help minimize invasion of undesirable and noxious plants and site deterioration through soil erosion. Costs are generally lower than on other seeding sites because the seedbed is already prepared by the disturbance.

Recommendations for seeding disturbed areas are based on findings in a survey of 84 areas in Oregon and Washington which had been seeded to grass following logging, on subsequent studies, and observations of large-scale plantings.

What Areas to Seed

Skid trails, landings, spur roads, cuts, fills and borrow pits along road, pipeline, and powerline rights-of-way, and other areas where the soil is disturbed and the native vegetation destroyed can be successfully seeded without further seedbed treatment (fig. 17). If the native vegetation has not been destroyed but only cut off at the ground line, seeding will not be successful because of competition from unkilled rhizomatous plants like pinegrass and shinyleaf spirea.

Before seeding grass on those ponderosa pine forest ranges where the principal management objective is growing trees, the benefits derived from seeding to grass should be weighed against possible competitive effects of the grass on pine seedlings. Although evidence is not clearly defined, dense stands of seeded grass are reported to compete with and possibly retard reestablishment of a timber stand on disturbed areas.

Successful procedures and adapted species have been found and are recommended for seeding most of the soil types in eastern Oregon and Washington. However, the recommendations do not cover disturbed areas with coarse pumice soils in central Oregon and the coarse glaciated soils of north central Washington. Successful results have not been obtained in these areas.

What to Seed

Several different species and mixtures can be used for seeding disturbed areas in the ponderosa pine zone.

Choice between mixtures depends on the dryness of the site, the intensity of grazing which can be expected, and how rapidly soil cover is needed.

The amount of ponderosa pine in the forest stand usually is an index to the dryness of the site. It grows in nearly pure stands on the drier sites, such as south slopes, but is found in company with Douglas-fir, white fir, grand fir, Pacific silver fir, and western larch on

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FIGURE 16.—Before (*A*) and after (*B*) seeding a cleared strip through forested range where a gas pipeline had been constructed. Seeding of such areas aids in preventing erosion and the establishment of noxious and other undesirable plants as well as producing forage for livestock and big game.

north slopes or where soils are deeper and moisture more abundant.

If heavy grazing can be expected after the plants are established, the mixture containing hard fescue is recommended. Hard fescue has low palatability for livestock and generally will not be killed out under heavy use. All mixtures contain timothy and orchardgrass because these species have done well on most disturbed areas. They are easy to establish by broadcast seeding and provide soil cover quickly.

The species and mixtures that can be used are shown in the following tabulation:

Forest subtype	*Mixture*	*Live, pure seed per acre (pounds)*
Ponderosa pine....	Hard fescue.....	3
(Stands in which	+orchardgrass.....	2
more than four-	+timothy.....	1
fifths of the trees	or	
are ponderosa	Topar pubescent	5
pine).	wheatgrass.	
	+orchardgrass.....	2
	+timothy.....	1
Ponderosa pine,	Intermediate wheat-	4
mixed fir, larch.	grass.	
(Stands in which less	+orchardgrass.....	2
than four-fifths of	+timothy.....	1
the trees are pon-	or	
derosa pine).	Manchar smooth	4
	brome.	
	+orchardgrass.....	2
	+timothy.....	1
	or	
	Tualatin oatgrass...	4
	+orchardgrass.....	2
	+timothy.....	1

Although not recommended here, crested wheatgrass has been successfully seeded on a few dry sites in the pine zone. Generally, however, crested wheatgrass has not done as well as the species listed in the tabulation.

Meadow or grassland areas disturbed during logging or construction can be seeded with species and mixtures recommended for those types.

When and How to Seed

Disturbed areas should be seeded in the same year the disturbance takes place. Areas disturbed in late spring, summer, and early fall should be seeded in the late fall, and those disturbed in the winter and early spring should be seeded in the spring.

Seed can be broadcast directly on recently disturbed areas without additional seedbed preparation. As the soil settles, it will cover the seed. If the soil surface has been crusted and compacted by rain or snow, it may be necessary to follow the broadcasting by harrowing. Seeding can be done with hand broadcasters, or with power broadcasters mounted on a 4-wheel-drive truck or similar vehicle.

Mechanical water diversion devices frequently are needed to help prevent erosion on steep areas. On steep skid trails, or other steep disturbed areas, water bars spaced 50 to 100 feet apart depending upon steepness of slope, will divert runoff from the disturbed area to adjacent areas covered with vegetation. Small unused logs, broken tops or heavy slash make good water bars if laid across the slope and backed in with soil. On some logged areas, small earth dams made by tractors equipped with dozier blades are effective. These dams need be only a foot or so high.

Water diversion devices should be installed before seeding so that seed and young plants will not be washed away during spring snow melt or heavy rains. When this happens expected benefits in forage production, erosion control and control of undesirable weeds are lost.

Seeding of meadows or grassland areas in the ponderosa pine zone in conjunction with seeding of disturbed areas frequently will lower overall seeding costs through more efficient use of time and equipment. In addition, grass will not have to be replanted where it was destroyed by heavy equipment traveling through meadows or grasslands adjacent to logging or construction areas.

Seeding Accidental Burns in Forested Zones

Fires sometimes kill all trees and other plants on forested areas in the ponderosa pine zone and at higher elevation in eastern Oregon and Washington. On

F-455852

FIGURE 17.—Steep skid trails, where the vegetation has been completely destroyed by tractors and log skidding, frequently erode. Grass seeding, combined with construction of water bars, brush or earth dams, will effectively reduce soil loss.

severely burned areas the litter may be completely consumed by the fire and even large roots of trees burned out of the soil. Soil loss from these burned areas can be serious during heavy rains or spring snowmelt because mountain soils often are highly erodible. Getting plant cover back quickly on the burned forest land is necessary to cut down soil loss and maintain the productivity of the site for watershed, timber, range, and other land uses.

Studies and large scale plantings have shown that grass can be successfully seeded (fig. 18) on most burned forest areas, with the exception of burns on coarse pumice and coarse glaciated soils. Grass will provide soil cover needed to help retard erosion, and at the same time

F-456200

FIGURE 18.—Broadcasting grass seed where forests have been destroyed by fires provides vegetation that helps protect the soil and watershed and, until trees can be reestablished, furnishes forage for game and livestock.

provide forage to replace that lost by the fire.

Before going ahead with a grass planting project on burned-over forest land, however, plans for seeding grass need to be correlated with plans to raise a new crop of trees. Many burned forest areas should be planted to trees, especially where timber values are more important than range values. Where this is the case, rapid-developing bunchgrasses will help protect the soil until trees can be reestablished.

What to Seed

The same mixtures recommended for seeding areas disturbed by logging and construction can be used in seeding burned areas in the ponderosa pine zone.

For high elevation burns in the lodgepole pine and mixed fir types, the following species and mixtures are recommended, based on findings in both small plot trials and large-scale plantings:

Mixture:	*Live, pure seed per acre (pounds)*
Blue wildrye	5
+redtop	2
+timothy	1
Chewings fescue	3
+Highland bentgrass	1
+Manchar smooth brome	3
+timothy	1
Red fescue	3
+orchardgrass	3
+redtop	2
Tualatin oatgrass	5
+timothy	1

Choice between mixtures depends on the main purpose of the seeding. If quick-starting species are desired to give soil protection until an area is planted to trees, the mixture of Tualatin oatgrass and timothy is recommended. Where sustained forage production is desired along with soil stabilization, the mixtures containing Manchar smooth brome or orchardgrass can be chosen.

Blue wildrye, chewings fescue, Highland bentgrass, redtop, and red fescue are particularly useful where long-time maintenance of ground cover is desired for erosion control. They have moderate to low palatability for livestock and can be expected to last. Blue wildrye also has the advantage of reseeding itself readily.

Several large-scale plantings which yielded worthwhile information on seeding lodgepole pine burns were located on the Big Cow Creek Burn, an area with volcanic ash soil at 6,500 feet elevation in eastern Oregon. In addition, small plot trials of 50 species and strains of grasses and legumes were planted there in 1939 and 1940. Detailed planting procedures and early results were reported in Oregon State Agricultural Experiment Station Circular 159, Reseeding Eastern Oregon Summer Ranges, which was issued in 1944.

The large plantings showed the advisability of planting a mixture containing both long-lived and quick-starting, short-lived species. The quick-starting species gave good soil cover soon after planting, while the long-lived species maintained good soil cover after the quick-starting, short-lived species had disappeared.

These large plantings also provided some worthwhile information on the effects of seeded grass on reestablishment of thickets of lodgepole pine. In 1942, 3 years after seeding, herbage production by a mixture composed of crested wheatgrass, Kentucky bluegrass, timothy, and white clover amounted to 977 pounds per acre, air-dry, of which timothy yielded 804 pounds. No lodgepole pine seedlings were found in this seeding. By 1946, herbage production had dropped to 358 pounds per acre and 87 lodgepole pine seedlings per acre were counted. Another area seeded with a mixture of slender wheatgrass, mountain brome, orchardgrass, and white clover yielded 624 pounds of air-dry herbage per acre and supported 174 lodgepole pine seedlings in 1942 compared to 2,439 pine seedlings per acre on an adjacent area not seeded to grass. In 1946, herbage production was 597 pounds while lodgepole pines had in-

creased to 305 per acre on the area seeded to grass. Counts of lodgepole pine were not made in 1946 on the unseeded area.

Both of these mixtures resulted in good initial soil cover and aided in retarding soil erosion. In addition, both initially retarded reestablishment of dense stands of lodgepole pine, although by 7 years after seeding, lodgepole pines had begun to invade the grass-seeded areas in appreciable numbers.

In 1950, the five best species on the small plots were blue wildrye, commercial tall oatgrass, red fescue, timothy, and commercial smooth brome. Fairly good stands of several other species grew on the area, but many of the species which had made good initial growth no longer showed up well in 1950. Some of these were characteristically short-lived plants which did not reproduce themselves.

When and How to Seed

Grass should be seeded in the fall of the same year of the burn, preferably before heavy rains settle ashes left by the fire. Grass broadcast seeded more than 1 year following a burn generally will not make a good stand unless additional seedbed preparation is provided. Grass sown into loose ashes will be satisfactorily covered when the ashes settle. If impossible to seed before ashes have settled, the grass should be sown as late as possible so that is will be covered by snow soon after sowing.

Seed can be satisfactorily broadcast with rotating type hand seeders, airplanes, or helicopters. Helicopers can be effectively used where slopes are steep. They can be flown close to the ground, resulting in uniform distribution of seed.

COMMON AND SCIENTIFIC NAMES OF PLANTS MENTIONED

GRASSES AND GRASSLIKE PLANTS

Bentgrass, Highland	*Agrostis tenuis* (strain)
Bentgrass, thin	*A. diegoensis*
Bluegrass, Kentucky	*Poa pratensis*
Bluegrass, Nevada	*P. nevadensis*
Bluegrass, Sandberg	*P. secunda*
Brome, cheatgrass	*Bromus tectorum*
Brome, Manchar smooth	*B. inermis* (strain)
Brome, mountain	*B. carinatus*
Brome, smooth	*B. inermis*
Brome, Bromar mountain	*B. carinatus* (strain)
Fescue, Alta	*Festuca arundinacea*
Fescue, chewings	*F. rubra* var. *commutata*
Fescue, green	*F. viridula*
Fescue, hard	*F. ovina* var. *duriuscula*
Fescue, Idaho	*F. idahoensis*
Fescue, red	*F. rubra*
Foxtail, meadow	*Alopecurus pratensis*
Hairgrass, annual	*Deschampsia danthonioides*
Hairgrass, tufted	*D. caespitosa*
Junegrass, prairie	*Koeleria cristata*
Needlegrass	*Stipa* spp.
Needlegrass, subalpine	*S. columbiana*

Oatgrass, tall	*Arrhenatherum elatius*
Oatgrass, Tualatin	*A. elatius* (selection)
Orchardgrass	*Dactylis glomerata*
Pinegrass	*Calamagrostis rubescens*
Redtop	*Agrostis alba*
Sedges	*Carex* spp.
Squirreltail, bottlebrush	*Sitanion hystrix*
Timothy	*Phleum pratense*
Wheatgrass	*Agropyron* spp.
Wheatgrass, bearded bluebunch	*A. spicatum*
Wheatgrass, beardless bluebunch	*A. inerme*
Wheatgrass, intermediate	*A. intermedium*
Wheatgrass, Primar slender	*A. trachycaulum* (strain)
Wheatgrass, slender	*A. trachycaulum*
Wheatgrass, Standard crested (desert wheatgrass)	*A. desertorum*
Wheatgrass, Topar pubescent	*A. trichophorum* (selection)
Wheatgrass, Whitmar beardless	*A. inerme* (selection)
Wildrye, blue	*Elymus glaucus*

LEGUMES

Alfalfa	*Medicago sativa*
Alfalfa, Ladak	*M. sativa* hort. var. LADAK
Alfalfa, Nomad	*M. sativa* hort. var. NOMAD
Clover, white	*Trifolium repens*
Vetch, perennial (bramble)	*Vicia tenuifolia*

WEEDS

Arnica, heartleaf	*Arnica cordifolia*
Eriogonum	*Eriogonum* spp.
Falsehellebore, California	*Veratrum californicum*
Gumweed, curlycup	*Grindelia squarrosa*
Knotweed, Douglas	*Polygonum douglasii*
Lupine	*Lupinus* spp.
Penstemon	*Penstemon* spp.
Pussytoes, rush	*Antennaira luzuloides*
St. Johnswort, common	*Hypericum perforatum*
Tarweed, cluster	*Madia glomerata*
Thistle	*Cirsium* spp.
Waterleaf, whiteface Fendler	*Hydrophyllum fendleri albifrons*
Wyethia	*Wyethia* spp.
Wyethia, mulesears	*W. amplexicaulis*
Wyethia, whitehead	*W. helianthoides*
Yarrow, western	*Achillea lanulosa*

SHRUBS AND TREES

Douglas-fir	*Pseudotsuga menziesii*
Fir, grand	*Abies grandis*
Fir, Pacific silver	*A. amabilis*
Fir, white	*A. concolor*
Larch, western	*Larix occidentalis*
Pine, lodgepole	*Pinus contorta*
Pine, ponderosa	*P. ponderosa*
Rabbitbrush	*Chrysothamnus* spp.
Sagebrush	*Artemisia* spp.
Sagebrush, big	*A. tridentata*
Sagebrush, low	*A. arbuscula*
Sagebrush, silver	*A. cana*
Spirea, shinyleaf	*Spiraea lucida*

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